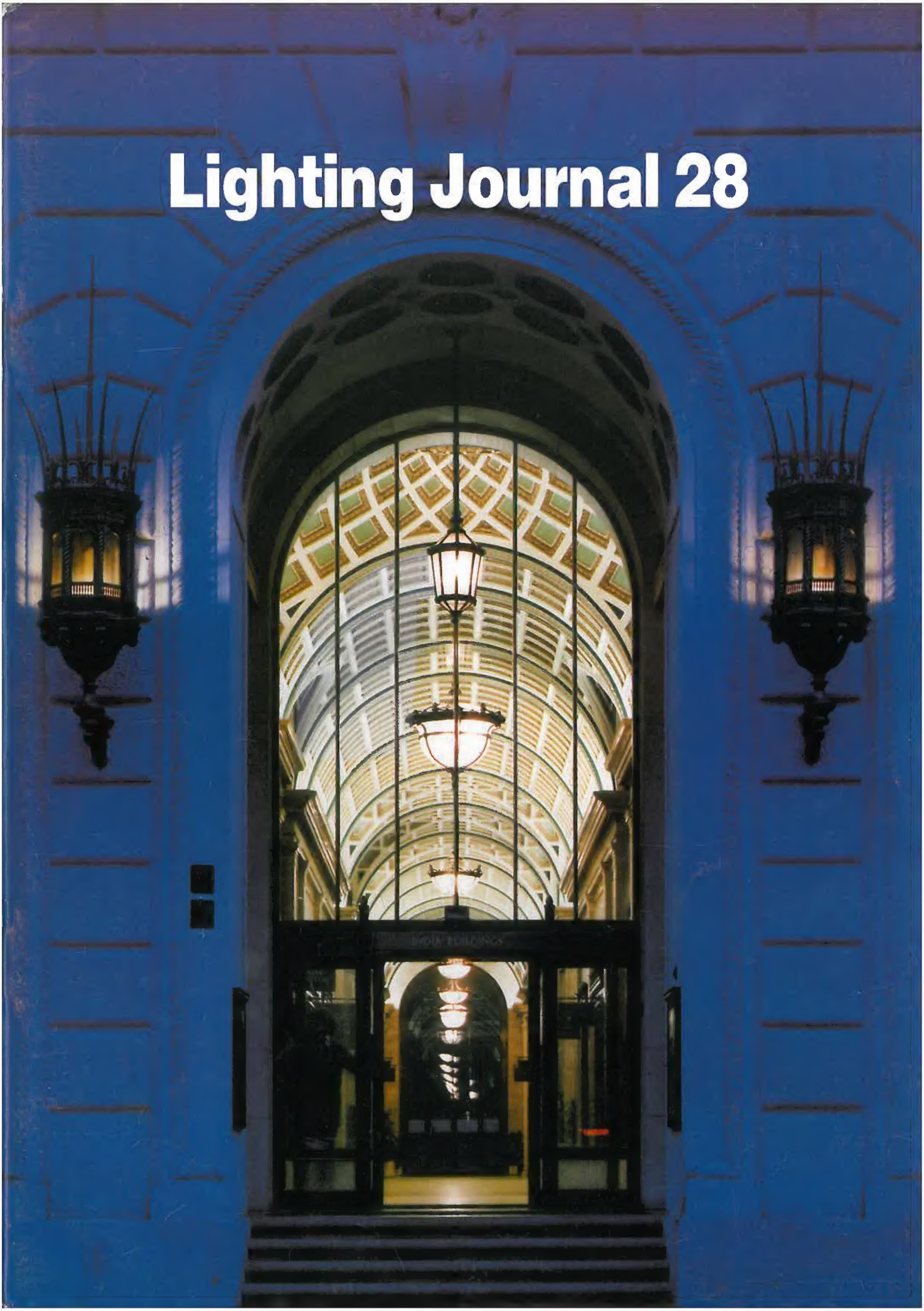
Lighting Journal 28




anvil
LIBERTY
PRESENTS
Dartington

Lighting Journal 28

Summer 1986

Front cover: **India Buildings in Liverpool has recently undergone a massive facelift. Exterior decorative bronze fitments have been renovated with 70W SON lamps while inside, the lofty entrance hall now creates an impression of grandeur, reflecting the opulent era of the great merchants. Over 100 fluorescent luminaires using Polylux 2700 lamps act as uplights located in perimeter pelmets. Massive Edwardian lanterns have been revamped with twin 150W SONDL lamps operating from remote mounted control gear.**

Inside front cover: **Anvil in Dulwich Village, London has used low voltage tungsten halogen lighting to complete an extensive refurbishment. A total of 29 luminaires with 50W 12v lamps, mounted on 1.2m sections of low volt track light the 60m² upmarket giftware shop. An exuberant window display has been created with green, blue, red and yellow colour filters.**

Back cover: **There seems no end to the variety of interior applications using de luxe high pressure sodium lamps. The central zone of Hulbert Middle School, Waterlooville, used for community activities, is lit with SONDL-T lamps in low bay luminaires.**

Inside back cover: **The Ice Bowl at Gillingham Business Park has been lit by an ingenious installation of stadia floodlights in uplight mode. Thirty eight 400W SONDL units are mounted on two suspended booms running the length of the hi-tech building. A service illuminance of 400 lux is provided for an electrical load of 16.6kW. In addition 500W tungsten halogen floods with colour filters provide attractive downward mood lighting when required.**

This issue of the Lighting Journal reflects the importance of 1986 which has been designated Energy Efficiency and European Road Safety Year.

We start with a look at the Lighting Industry Federation's Energy Management In Lighting Awards Scheme (EMILAS). These detailed case studies illustrate how energy can be conserved while lighting standards are improved. It is followed by an article describing how the use of electronics has led to a major advance in fluorescent lamp technology. The advent of the high frequency electronic ballast opens the way for greater flexibility and efficiency in lighting installations.

Good road lighting is known to reduce accidents and the emphasis on energy conservation has given it added importance. The article on this topic examines the development and progress of the high pressure sodium lamp and how this has upgraded road lighting standards.

Of great importance to all users of lighting is quality, in the form of reliability, safety and performance. Luminaires have to withstand a variety of physical conditions including vibration, dust, moisture, variations in temperature and sadly, vandalism. In this issue we take a look behind the scenes at the work of Brock Hoaran in material testing and analysis.

The final two articles return to the theme of actual practice by describing the importance and application of special luminaires and the floodlighting of one of Hong Kong's most prestigious buildings. A brief review of installations, both home and abroad, completes this 'new look' issue that we hope will provide something of interest for every reader.

Contents

Published by
THORN EMI Lighting Ltd
Publicity Department
284 Southbury Road
Enfield
Middlesex
EN1 1TJ
Printed offset litho by
Robert Pearce & Co Ltd
Designed by Zee Creative Ltd

THORN EMI
A world authority on light

EMILAS

The Energy Management in Lighting Awards Scheme (EMILAS), sponsored by the Lighting Industry Federation, includes sections for new schemes and the conversion of old industrial and commercial ones. The awards are "for improving the efficiency of electrical usage for lighting and to encourage good energy management practice for lighting installations". Since 1977 the total energy savings effected by the scheme, attributable to 2,648 entries, amount to 150 million kWh which is equivalent to over £7m per annum.

This year THORN EMI Lighting installations won one major section and six other schemes were highly commended.

Winner, New Schemes section

CATNIC COMPONENTS

Yeovil

This factory, manufacturing garage doors and accessories won the New Scheme section. The assessor's report states this as having all the hallmarks of a well thought out and executed lighting scheme. It is a very good example of modern, light industrial practice, providing good visual conditions in a clean environment.

The installation comprises one hundred and eighty one 400W de luxe high pressure sodium tubular lamps (SONDL-T) in low bay luminaires, which provide an average illuminance of 580 lux for a total electrical load of only 79kW. Efficiency is 63.1 lux per W/m^2 and a photocell control system operates.

Highly commended, New Schemes section

SCOTTISH EXHIBITION AND CONFERENCE CENTRE

Glasgow

The new Scottish Exhibition and Conference Centre claims to provide the most up to date facilities in Europe and certainly it leads the way in energy saving.

Two hundred and sixteen high bay luminaires with 400W SONDL-T lamps have been installed in pairs enabling two levels of lighting, 500 lux and 250 lux to be obtained via a straightforward switching arrangement.

The SONDL-T equipment which gives extremely good colour rendering for all types of exhibitions was chosen after extensive field trials. Total energy loading is 94.2kW and efficiency is 59.5 lux per W/m^2.

Highly commended, New Schemes section

IPSWICH CO-OPERATIVE SOCIETY

Felixstowe

Ipswich Co-operative Society's new Solar Superstore required excellent colour rendering and a high level of illuminance, together with efficiency and flexibility. The 1266m^2 sales area has been equipped with 138 fluorescent luminaires using twin 2400mm 100W Polylux 4000 lamps, amounting to 850 lux at 31kW. Efficiency is 35 lux per W/m^2. The scheme also includes a number of 16W2D compact fluorescent downlights.

Highly commended, New Schemes section

DUDLEY METROPOLITAN BOROUGH COUNCIL

Dudley

One hundred and fifty seven recessed Arena 2 luminaires using twin 36W 1200mm Polylux 3500 fluorescent lamps with low brightness reflectors light this office. The lighting equipment gives an average illuminance of 800 lux for 14.8 kW. Efficiency is 43.1 lux per W/m^2 and a computer controlled energy management system achieves high standards of energy management.

Highly commended, Industrial section

ENTERPRISE ENGINEERING

Stockport

The welding shop of Enterprise Engineering is now lit by 40 low bay luminaires, housing a combination of 250W and 400W SON-T lamps. The old scheme consisted of 40 high bay luminaires, each using a 500W tungsten lamp and 400W mercury (MBF) light source. Lighting load has dropped from 37.3 to 12.9kW while service illuminance has risen from 60 to 350 lux – a sixfold increase. Lux per W/m^2 increased from 2.8 to 47.9. The new lighting also brings the additional benefit of maintenance savings, due to the extended lamp life of SON.

Highly commended, Commercial section

CIVIL AVIATION AUTHORITY

Stansted

The Civil Aviation Authority's Stansted aircraft hangar has been re-lit by a total of 35 high bay luminaires using 400W SONDL-T lamps. These provide a service illuminance of 500 lux for an installed load of 15.2kW. This amounts to a 233 per cent increase in illuminance compared with the twenty one year old scheme of 20 co-mounted 1kW tungsten filament and 400W MBFU mercury lamps, while energy usage has decreased by 50 per cent. Local lighting often used beneath aircraft wings is now unnecessary and the new lighting also brings the additional benefits of maintenance savings with a substantial increase in lamp life. Efficiency is 62.5 lux per W/m^2 previously being 9.5

Highly commended, Commercial section

STERLING ORGANICS

Cramlington

This is the first entry using compact fluorescent lamps to gain an EMILAS award. The installation, in the staff restaurant, comprises sixty eight 2D 16W lamps in recessed downlights, which provide an average illumination level of 200 lux for a power consumption of only 1.4kW. The original scheme of 68 power hungry 150W tungsten reflector spots consumed 10.2kW for 150 lux. Efficiency is 37.3 lux per W/m^2 formerly being 3.9. Relamping will be greatly reduced due to the 2D's 5000 hour life, five times that of tungsten.

PETER DAVENPORT

Electronic Technology in Fluorescent Lighting

The application of electronics to lighting is not new. For transport, emergency and theatrical lighting, electronics have been widely used for many years. Discharge lamps of all types are commonly started by electronic means, but for mains supplied tubular fluorescent lighting developments are only just beginning to appear. Electronic circuits have now been developed that provide close to ideal control characteristics giving greater opportunities for increased efficiency and energy saving. Two types of device are available: starters and more recently, ballasts.

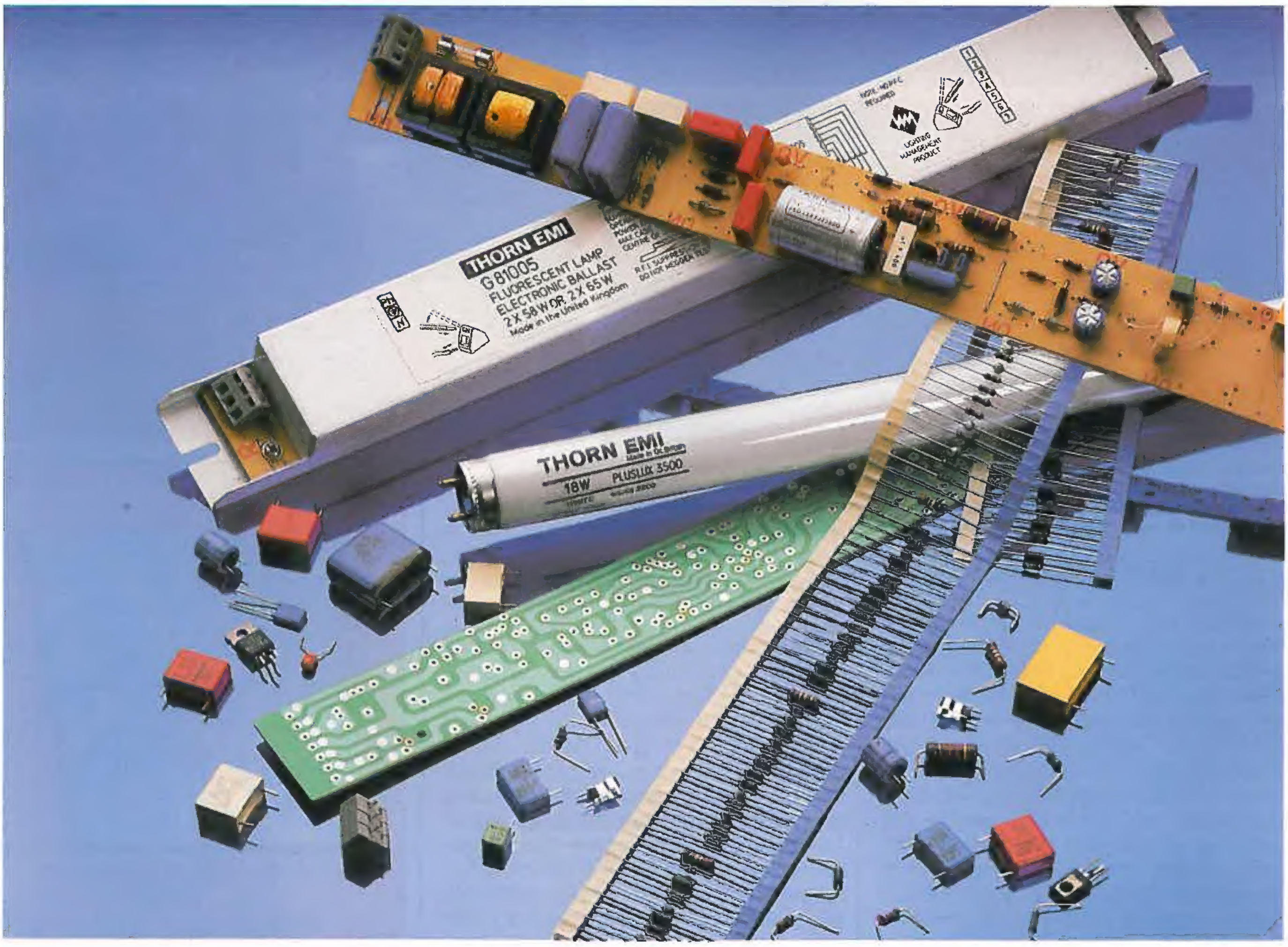
Mr Davenport is Product Manager (Electronics) of THORN EMI Lighting at Enfield

CONVENTIONAL CIRCUITS ASSESSED

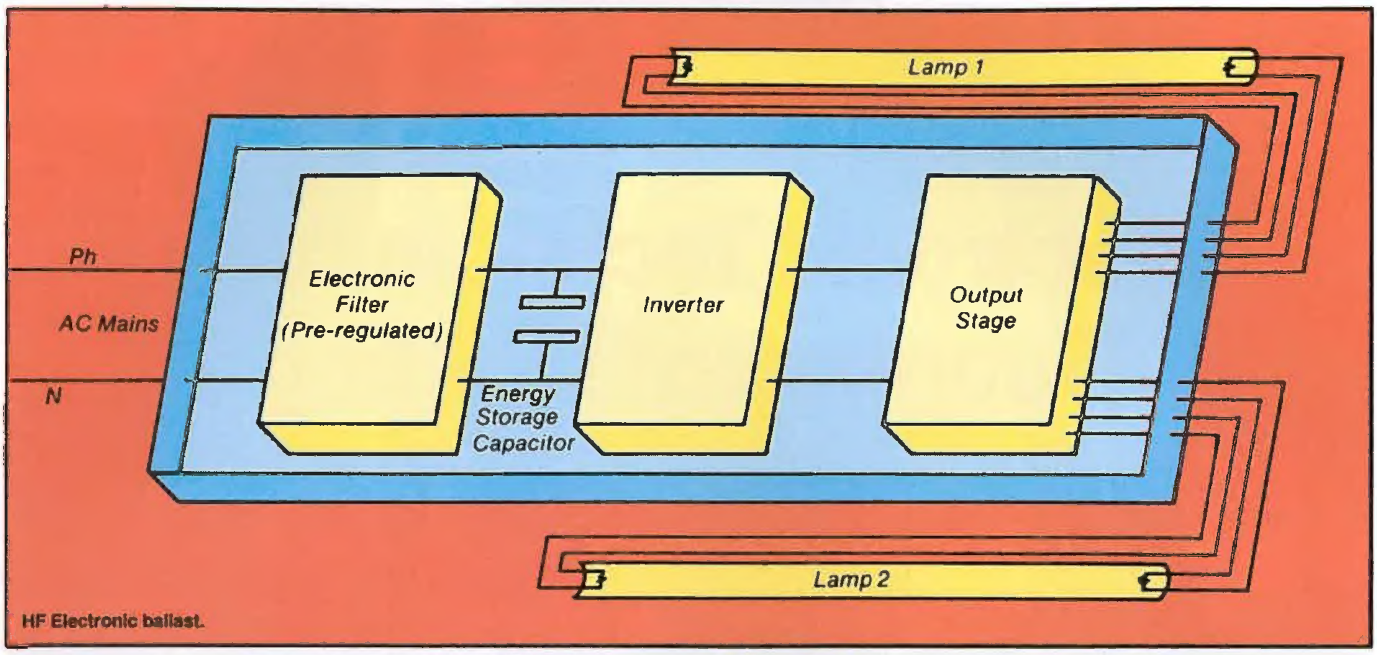
Before examining in detail these latest advances it is beneficial to review, albeit briefly, basic fluorescent lighting control gear.

A fluorescent tube requires a means of starting and a device to control the current once the arc has been established. Lamps operated from an AC supply usually meet these requirements by employing a 'glow bottle' starter switch and a wire wound coil or inductor called the ballast or choke. Consequently a capacitor is required to give an acceptable power factor. The circuit is inexpensive, simple and reliable. The disadvantages are size, weight, power losses and the need for periodic replacement of the starter switch.

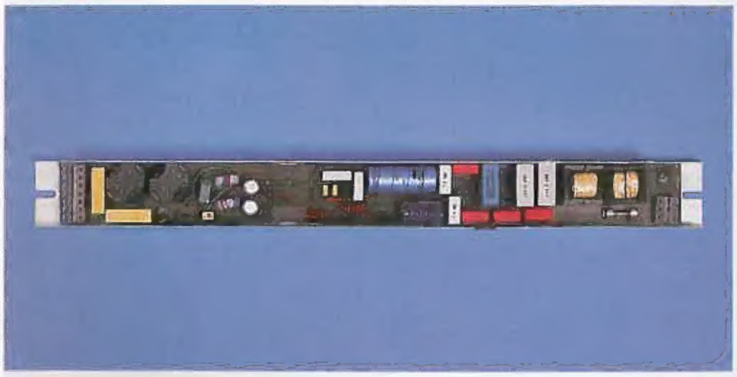
A further, more obvious drawback is some uncertainty in starting, characterised by a 'blinking' or 'flashing' of the tube – typically three or four times before it lights. There are also other problems, less obvious to the casual observer. Towards the end of life star-

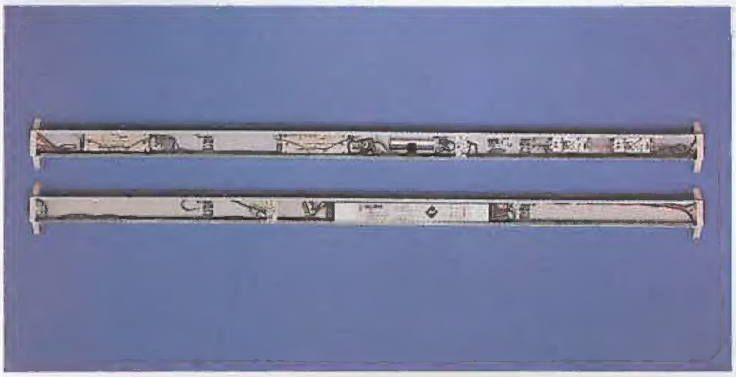


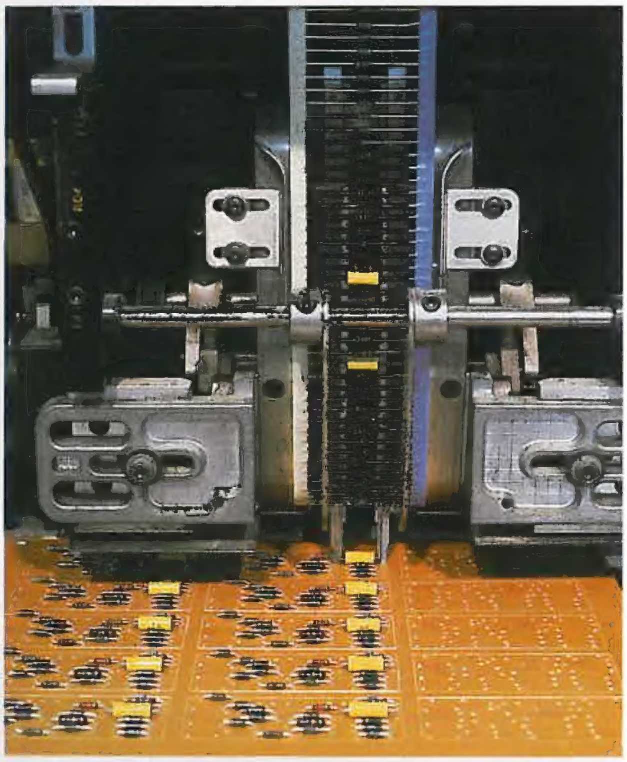
The picture opposite illustrates the high frequency electronic ballast production at Spennymoor, Co Durham. Ribbon strips of electronic components are automatically arranged in the required sequence.
Above: **The variety of components involved in the modern electronic ballast.**



HF Electronic ballast.





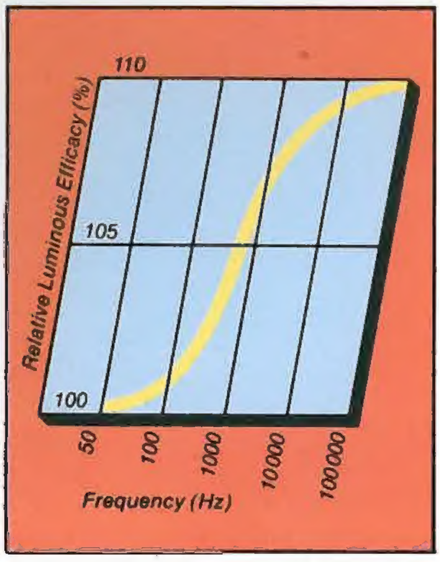


Left is an exploded view showing electronic ballast component layout. Below this, is seen a comparison between twin fluorescent luminaires, one using traditional wire wound gear, capacitor and electronic starter, the other an electronic ballast. Shown right is the precision insertion of components into printed circuit boards at the Spennymoor factory. Capacity is 20,000 units per hour.

ters can operate too quickly causing 'cold starting' or fail in a 'stuck starter' condition with welded contacts both of which may adversely affect both lamp and ballast as well as electricity costs. This type of circuit has been used throughout Europe, but for the UK and USA, other starterless circuits have been popular. One such example is the semi-resonant start (SRS) circuit which does away with the starter switch and employs a specially wound transformer ballast. The circuit however is unsuitable for the latest generation of 26mm diameter energy saving krypton tubes and furthermore electricity costs for 38mm diameter tubes are higher than with switch start circuits.

ELECTRONIC CIRCUITS

Electronic starters have proved effective, combining the best features of both types of circuit. The problems of slow pulse repetition of the thermally controlled glow bottle starter have been overcome to give a crisp first time start. A rapid chain of pulses is applied which start the lamp within 1.5 seconds and automatic 'shut-down' occurs in the case of a failed lamp. Simply it offers far better reliability and life than a starter switch and a more efficient and universal circuit than SRS. This circuit was described in detail in Lighting Journal 26 (Winter 1983).



Variation of light output with frequency.

One hundred and eighty twin 1500mm fluorescent luminaires, with electronic ballasts, light the BAA's new terminal building at Stansted Airport. The electrical load, so vital with 24 hour operation, is a mere 20kW and service illuminance 600 lux.

INTRODUCTION OF THE ELECTRONIC BALLAST

The recently introduced high frequency electronic ballasts provide instant flicker-free starting for single and twin standard fluorescent lamps up to 1800mm in length, both 26mm and 38mm in diameter. However, modern electronic technology has taken the concept of control gear further, to the extent that these new ballasts eliminate altogether the need for separate starter, choke and capacitor. Further quality features are thus possible. For example compared with two sets of control gear weighing some 2kg an electronic ballast's mass is a mere 600g, thus providing new opportunities in luminaire design and reducing loadings on ceiling and other support systems.

THE NEED TO REDUCE HARMONIC DISTORTION

One major problem to solve with electronic ballasts is harmonic distortion on the mains supply. This is unacceptable to electricity supply authorities and without filtering gives rise to leading power factors as low as 0.55. At first manufacturers overcame this by use of an inductive 'filter ballast' to bring the current waveform back to near sinusoidal form. However these are often heavier and bulkier than the conventional ballasts. Modern ballasts use electronic means to achieve a satisfactory waveform to comply with CISPR and IEC specifications and ensure that there are no electro-magnetic interference (EMI) and radio interference (RFI) problems. The end result is low harmonic distortion and a power factor near unity: typically 0.98 without the need for a separate correction capacitor.

BASIC PRINCIPLES OF AN ELECTRONIC BALLAST

The basic construction of a typical electronic ballast involves a harmonic filter, rectifier and inverter, similar to those used in emergency lighting. The principle of operation is to convert 50 or 60Hz mains input into a DC voltage and then convert this to a high frequency, around 32kHz, for operating fluorescent lamps. The ballast takes advantage of a characteristic of fluorescent lamps whereby greater efficacy is obtained at high frequency. The overall lighting system efficacy can be increased by 20 to 30 per cent due to three main factors:

1. Improved lamp efficacy at high frequency operation.
2. Reduced circuit power losses.
3. Lamp operates closer to optimum performance in most enclosed luminaires.

Efficacy due to high frequency operation is increased by about 10 per cent thereby enabling the lamp to be operated at a lower input power than at 50Hz. For instance, an 1800mm lamp normally rated at 70W with standard control gear can now be run at 62W for the same light output. The net effect of lower power in a typical luminaire is that useful light output is maintained.

Ballast losses are reduced compared to wire wound units as the solid state circuit contains no conventional copper windings. In the case of a twin

The 'Magic Eye' is an automatic light switch for controlling luminaires where the daylight factor is high.

1800mm circuit the losses can be reduced from 26W (starter switch circuit) to a mere 8W when using an electronic ballast. The overall achievement in a suitable luminaire, therefore, is an energy reduction in the region of 20 per cent for 26mm diameter (krypton) tubes and up to 30 per cent when using 38mm diameter (argon) tubes. Together, these energy saving features enable lighting levels to be maintained with a dramatic cut in electricity costs. With less heat generated, the load on air conditioning equipment will also be reduced.

IMPROVING THE VISUAL ENVIRONMENT

The high frequency electronic ballast has other important contributions to make in advancing the quality of the interior environment. As the system has almost no 50Hz or 100Hz components in the output to produce unwanted modulation of light, there is no flicker or stroboscopic effect. Operation is silent because there are no choke laminations and windings as in conventional circuits.

When the lamp is switched on the circuitry ensures that the lamp is started under the most favourable conditions for good lamp life. This ensures ionisation and efficient starting without compromising lamp life or creating conditions which lead to 'end blackening'.

QUALITY AND RELIABILITY

Considerable effort has also been put into translating the circuit into a well engineered device. Manufacture of reliable electronic products is vital to give users the same degree of confidence as they have traditionally enjoyed.

THE IMPORTANCE OF LIGHTING MANAGEMENT

Industrial and commercial installations such as factories, shops and offices can benefit from significant reductions in energy consumption. In commercial premises alone, lighting represents about 45 per cent of the electrical energy consumption. Maintenance of installations is also simplified eliminating expensive on-site diagnosis of several circuit elements.

Lighting increasingly will be about systems in which forms of switching, control, optics, light source technology and circuits require co-ordination. Combining these developments correctly will permit high quality lighting to be achieved with low energy consumption and flexibility of control. Already luminaires are employing optical systems, electronic ballast circuitry and more efficient light sources. The electronic ballast moves lighting one stage nearer the ideal of a completely integrated system; with one device both starting and running the lamp. In future it is likely to include degrees of switching and light level control to interface with energy management systems.

CHOOSING A SYSTEM

There has emerged a plethora of energy management systems to suit differing needs ranging from relatively low cost options to highly expensive computers. At the top end are the comprehensive systems which not only handle dedicated control functions but provide data to assist energy managers in monitoring and targeting energy conservation.

Microcomputer or microprocessor based devices with local receivers tend to be lower in cost, suited to medium sized buildings, but retain the central control principle. Such systems dedicated to lighting control are finding increasing applications, seeking to provide lighting only when it is required but without reducing lighting standards. This represents a significant advance on the earlier practice of lighting treated merely as a connected load, with pre-arranged circuits simply being disconnected to avoid incurring maximum demand tariffs.

It has become necessary during a period of change in practice to ensure that alternative methods of control are compatible with the lighting equipment. One thing is certain, the ubiquitous wall switch is no longer the only means of switching lighting. Many very successful lighting control schemes have been completed, benefiting particularly where the design of the lighting scheme has been developed in conjunction with that of the control system.

Research has shown energy savings relate particularly to occupancy and the availability of daylight. Whilst central control has a high correlation with occupancy (and can include a daylight control input) a localised photocell unit can also demonstrate a simple and effective means of control.

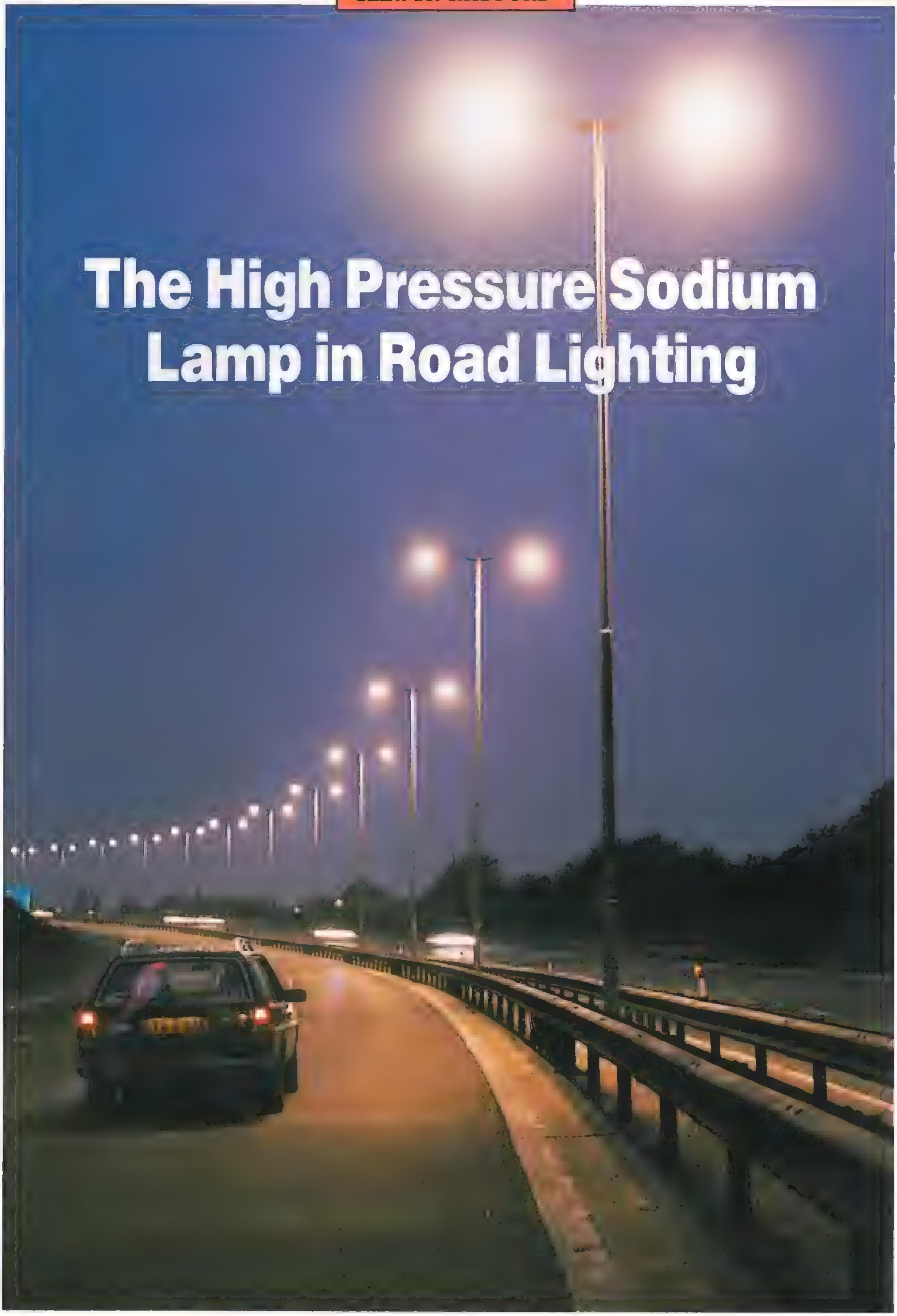
The photocell detects the amount of daylight in the task area and automatically switches off the luminaires when a sufficient level is reached. If daylight fades the lighting is restored. Installations using such devices on the row of luminaires close to windows have shown annual energy savings of up to 45 per cent.

FUTURE TRENDS

The way is now open for greater flexibility and efficiency in lighting installations and improved quality in the interior environment. Development is likely to increase in pace, as ingenuity in the use of electronics in lighting expands the demand for more sophisticated control and greater integration of systems. This is sure to herald a new era in lighting technology and practice.

SELWYN RADFORD

The High Pressure Sodium Lamp in Road Lighting



Forty years ago many roads looked like this. The picture opposite shows a remarkable change. A stretch of the M4 relit with 250W SON from 180W SOX gives 'instant' improvements in night time lighting and an overall reduction in running costs. Daytime appearance is improved and the longer lamp life means fewer lane closures and greater safety.

It has been accepted for many years that good road lighting makes a valuable contribution to road safety. Up to a 30 per cent saving in night time accidents can be achieved using the effective yet economic principle of lighting the road surface to reveal pedestrians and traffic in silhouette. Research carried out by the Transport and Road Research Laboratory confirms that the higher the average road surface luminance provided by the lighting, the lesser the risk of night time accidents.

A GLANCE INTO THE PAST

Since the introduction of discharge lamps it has gradually become less costly to provide good road lighting. The initial breakthrough came in the thirties with the use of mercury lamps to replace tungsten filament and gas installations. During the forties, improved mercury lamps with colour rendering became available. This period also saw the introduction of the 5ft tubular fluorescent lamp (requiring huge multi-lamp luminaires) in areas where good colour was considered important. Low pressure sodium lamps, giving a monochromatic, yellow light with no colour rendering properties, became firmly established in the fifties and sixties although various versions had been available since 1932. The choice was between the high efficacy of low pressure sodium and the long life and good colour properties of mercury and fluorescent lamps. Nowadays, fluorescent installations which were temperature sensitive and unsightly, are rare having been replaced by modern mercury and high pressure sodium (SON) lamps. When SON lamps were first introduced they were made to the same dimensions as the coated elliptical mercury lamps for easy conversion. The present situation in Europe is that virtually all new schemes use high or low pressure sodium, the usage of the former increasing all the time.

Mr Radford is Special Projects Engineer (Street Lighting Department) of THORN EMI Lighting at Enfield

DESIRABLE FACTORS

The most important considerations in the choice of a lamp for road lighting are:

1. High efficacy
2. Long life
3. Good colour

Although low pressure sodium (SOX) has the highest efficacy of any lamp made for general use, it does not have the long life or colour qualities of SON. Recent developments include SOX economy lamps, which further increase efficacy at the expense of lower light output and higher cost.

DEVELOPMENT

In 1957 it was shown that if the vapour pressure of a sodium lamp is raised, a high efficacy could be achieved with much improved colour qualities. However, although these results could be obtained under laboratory conditions a practical lamp could not be made. This was because a suitable 'glass' enclosure could not be made which would withstand attack by the high pressure sodium vapour. A breakthrough came in the form of a new material, translucent alumina. This enabled the construction of an arc tube which was inert to hot sodium vapour and SON lamps thus became commercially available in the late sixties.

The virtues of the SON lamp are by now well known. It has a long life, with excellent lumen maintenance, gives a warm white light and has a high efficacy. Moreover, the small arc tube enables accurate optical control and the use of compact lanterns. The range of lamp sizes available covers all the requirements needed for road lighting, typically from 50W to 400W.

The lamp size allows a smaller luminaire to be designed which in turn improves the degree of sealing, with consequent maintenance savings and gives greater opportunities for high

Alternative view of the M4 near Windsor. The excellent illumination level has allowed the photographer clearly to define moving vehicles, which number some 100,000 per day.

standards of optical performance. In addition, the control gear can conveniently be contained within the luminaire. The enclosure of the control gear in the luminaire offers a better environment for long life than when mounted in a damp column base compartment. Additionally if a photocell socket is to be mounted on the luminaire then it needs the minimum of extra wiring.

MOTORWAY LIGHTING

In this country the lamp most used at the present time for lighting motorways is the 180W SOX lamp. On the face of it this seems the most economic lamp to use, because its efficacy is 143 lumens per circuit watt, compared with 100 lumens per circuit watt for the SON lamp. But there are many features of the SON lamp which outweigh this apparent advantage. Most important is the life, which is double that of SOX. This, combined with the fact that the price of a SON lamp is only two thirds of a SOX lamp, means that replacement costs for SON are only one third of those for SOX. The lane closures needed for relamping cause major delays and dramatically increase the probability of accidents. With SON lamps the incidence of lane closures is halved.

Another important consideration is that it is possible to control the light more effectively from the small arc tube of the SON lamp than it is from the very long SOX lamp. This can readily be seen from the downward light output ratio, typically 83 per cent for a SON luminaire against only 75 per cent for a SOX luminaire.

A detailed costing analysis (see Table 1) taking all these factors into consideration shows the SOX installations to be 30 per cent more expensive, with energy costs at 4p per kilowatt hour.

The substantially whiter light from the SON lamp is much more acceptable than the monochromatic yellow of the SOX lamp, both for the driver and those who live in the vicinity of a motorway. Moreover, the smaller luminaire gives a much neater appearance in daytime.

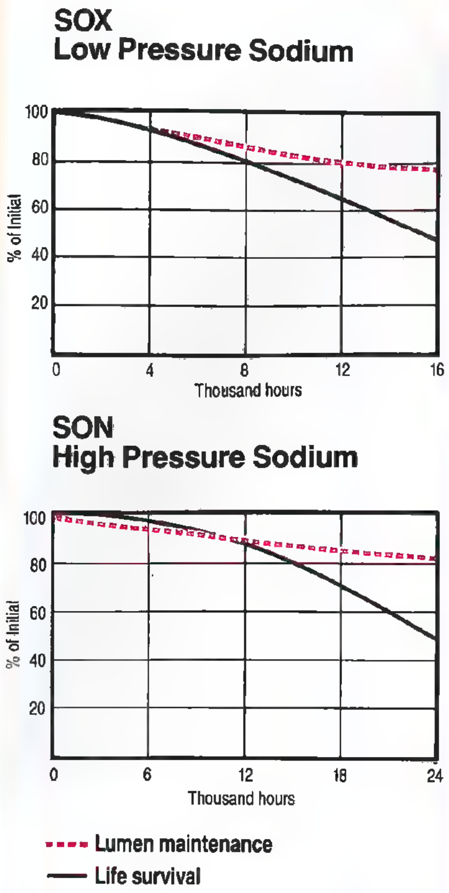
In referring to motorway lighting schemes, of particular interest is the new M4 relighting. The existing 180W SOX installation at the end of its life has been replaced with SON. The scheme, carried out by Berkshire County Council for the Department of Transport, costing £220,000, involved the replacement of 1,000 luminaires and 500 columns on a stretch of the M4 over ten miles in length, between points east of Junction 5 to west of Junction 8/9. The new 250W SON lighting was chosen on the basis of lower capital and running costs when compared with an equivalent scheme for SOX lighting. Column costs were also reduced due to the lower wind loading of the new luminaires. The saving in capital costs for the new scheme was £40,000. The longer life of the SON lamps will considerably reduce delays and hazards to motorway traffic, caused by lane closures for lighting maintenance. After the installation was completed, measurements were made of the photometric performance of the installation. There was excellent agreement between measured and calculated average luminance values, these being 2.5 and 2.4 cd/m^2 respectively.

LAMP LIFE

One of the most important factors in arriving at total running cost is lamp life and mortality curves are used to give a guide as to the failure rate to be expected for a given life. The curves are based on information obtained from factory life tests and field experience (see Fig 1). The first curve shows the performance of the range of SOX lamps from which we can see that for a period of 8,000 hours, an average of 20 per cent failures can be expected. For SON we see that for 20 per cent failures the life will be 16,000 hours. This indicates that for equivalent failure rate the life of SON is twice that of SOX.

It is clear from field experience that the large size and comparative fragility of the SOX lamp when used for Group A lighting is a major factor in reducing life. In contrast, the SON lamp's compact size has been the reason for its choice in the most adverse operating conditions on bridges such as the Forth, Humber and Severn.

Fig 1: **Lumen maintenance and life survival curves for SON and SOX.**



GROUP A ECONOMICS

The economic and lighting performance comparisons of 135W SOX and 150W SON are of particular interest. A comparison of costs is shown in Table 2. The cost of SON lamps is less and also the total circuit watts are the same at 175W. In cases where an Area Electricity Board's tariff is higher for SON it is compensated for by the lower annual lamp cost. Although the lamp lumens are less for SON, better utilisation of lamp flux can be achieved in reflector design because of the small source size. Comparisons have been prepared for several authorities to assist them in the determination of future lamp usage. In each case a decision has been made to adopt 150W SON instead of the previously used 135W SOX for future ten metre mounting height schemes. This conclusion has been reached on the basis of equal lighting performance at lower overall cost.

CITY CENTRES

SON lamps have become the most common form of road lighting for city centres. The good colour rendition of SON enhances the urban environment whereas mercury lighting tends to be cold and uninviting and SOX makes distinguishing colour virtually impossible.

Table 1: **Running costs for lighting a motorway over a ten year period.**

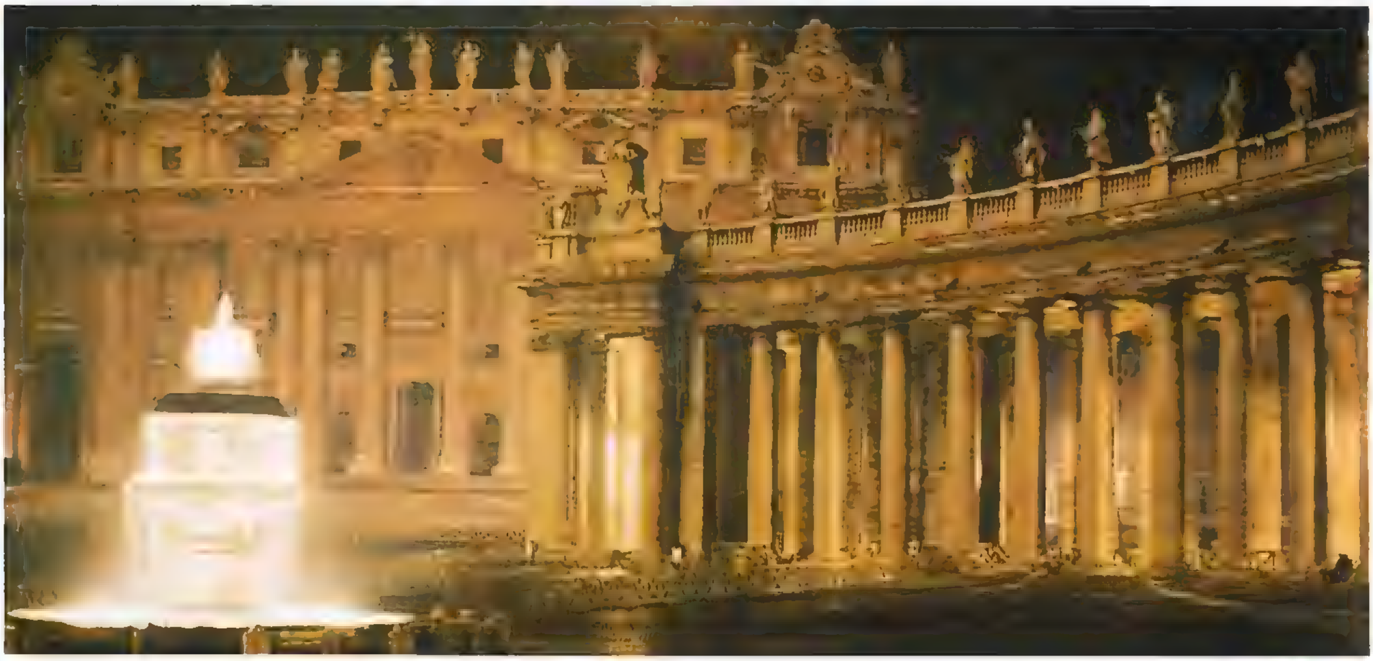
Twin Central Arrangement
3.6 m central reserve
1 kilometre length

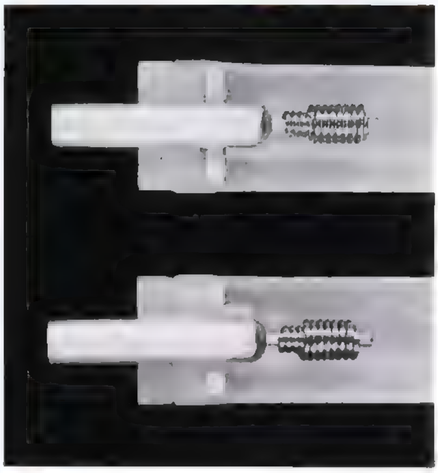
2 × 10.8 m three-lane carriageways
12 m mounting height

Ref	Item	180W SOX	131W SOX-E	250W SON-T
A	Luminaire type	Typical	Typical	Alpha 8
B	IP Category	IP54	IP54	IP54
C	Maintenance Factor	0.83	0.83	0.83
D	Lamp lumens (2,000 hours)	31,500	25,175	27,000
E	Lamp burning hours for 90% survival	4,000	4,000	8,000
F	Spacing for 2 cd/m² (m)	36.0	29.0	39.0
G	Lanterns per kilometre twin central (2,000/F)	55.0	69.0	51.0
H	Number of replacement lamps per lantern per ten years	10.0	10.0	5.0
I	Number of replacement lamps per ten years (G × H)	550.0	690.0	255.0
J	Cost per lamp (nett) (£)	20.27	24.32	13.52
K	Replacement cost per ten years (£) (I × J)	11,149	16,781	3,448
L	Labour charge at £15 per change (£) (15 × I)	8,250	10,350	3,825
M	Total replacement cost (K + L)	19,399	27,131	7,273
N	Electrical load per lamp (watts)	220.0	151.0	277.0
P	Running time (hours)	40,000	40,000	40,000
Q	Energy used per ten years (kWh) (P × N × G/1,000)	484,000	416,760	565,080
R	Energy cost at 2p per kWh (£) (Q × 0.02)	9,680	8,335	11,302
S	Energy cost at 4p per kWh (£) (Q × 0.04)	19,360	16,670	22,603
T	Energy cost at 6p per kWh (£) (Q × 0.06)	29,040	25,006	33,905
U	Replacement plus energy costs @ 2p per kWh (£) (M + R)	29,079	35,466	18,575
V	Relative cost (%)	157	191	100
W	Replacement plus energy costs @ 4 per kWh (£) (M + S)	38,759	43,801	29,876
X	Relative cost	130	147	100
Y	Replacement plus energy costs @ 6 per kWh (£) (M + T)	48,439	52,136	41,178
Z	Relative cost	118	127	100

Lamp Type & Wattage	135W SOX	150W SON.T
Mounting Height m	10	10
Minimum Downward Lumens (Codes of Practice)	12,000	12,000
Lantern Downward Lumens No.	15,900	12,555
Energy £	26.86	26.86
Lamp Replacement	6.41	3.67
LAMP & ENERGY COST £	33.27	30.53
Labour for lamp replacement £	5.00	3.33
Capital Borrowed Repayment £	8.95	7.19
TOTAL ANNUAL COST £	**47.22**	**41.05**
% Ratio	115	100

Table 2: **Cost comparison of 135W SOX and 150W SON-T. Assumes 4,000 lamp burning hours per annum, with group replacement SOX/SOX-E 8,000 hours; SON-T 12,000 hours. MANWEB Tariff.**





GROUP B LIGHTING

For Group B lighting, 50W and 70W SON lamps with external ignitors are becoming the dominant light source for five and six metre mounted height schemes. The long lives now being achieved for these lower ratings make them superior to the SOX lamps, which have never been considered entirely satisfactory for Group B lighting. The improved performance of 70W SON lamps is the result of the use of a new type of arc tube, only 4mm in diameter, which contains an insulating end plug invention.

CONCLUSION

The SON lamp can be described as embodying the most advantageous features of both the earlier SOX and mercury lamps. It is now recognised as the lamp type which will be used widely in the future for both interior and exterior installations, since it has the three desirable attributes of high efficacy, long life and good colour. It is being progressively developed to improve its characteristics and as such should be the preferred choice for all new and replacement schemes.

St Peter's Square, Rome, relit with SON lamps is shown at the top of this page. Below is West Berlin's city centre lit in a similar fashion. Both cities have instigated major modernisation and renovation programmes for pedestrian precincts and streets. While to the left is a close up of the 'stepped plug' innovation which prevents rectification occurring in low wattage SON lamps.

BROCK HOARAN

Reliability in Service

INTRODUCTION

THORN EMI Lighting luminaires are subjected to a wide range of tests in accordance with national and international standards, such as BS 4533 (1981) and VDE 0710. These standards ensure that the luminaires are safe as regards their electrical, mechanical and thermal properties. However, a deterioration in performance or appearance of any luminaire occurs during its service. This may be the result of attack from the environment or the lamp within the luminaires itself. Additional tests are therefore applied to ensure that these factors are controlled.

"Life tests", whereby luminaires are run for periods of up to ten years, are carried out as a matter of course. The experience and information gained is then used for improving or updating luminaires. However, changes in technology and innovations imply that accelerated testing is often required if these are to be successfully incorporated in new designs. The purpose of this article is to describe some of these tests but, in the first instance, some of the factors that cause the breakdown or deterioration of luminaires are considered.

Mr Hoaran is Section leader, Materials Research and Development of THORN EMI Lighting at Enfield

LUMINAIRE ENVIRONMENT

The atmosphere in which different luminaires may be expected to function can range from a dry, warm interior to the hostile conditions prevailing on offshore oil rigs. Even more hazardous areas may be encountered in nuclear reactors, where luminaires are subjected to bombardment from gamma or neutron radiation or in chemical works where luminaires may be in direct contact with aggressive fumes and vapours. In the "normal" external environment, deterioration usually results from sunlight and rainfall, although factors such as vandalism, vibration, corrosion, abrasion and contamination from airborne debris such as dust and dead insects cannot be overlooked. Damage can also occur from within luminaires as the result of ultraviolet (UV) radiation emitted by the light sources in addition to heat from components such as ballasts.

UV DEGRADATION

Today, since a large number of plastics are used in the construction of luminaires, UV attack is one of the main causes of breakdown and impaired performance. The reader may already have witnessed this phenomenon in other areas without realising its cause. Typical examples are embrittled, cracked or faded seat covers in automobiles, discoloured and "crazed" washing-up bowls and "perished" hosepipes. In luminaires, the effects of UV damage are no different although considerable efforts are made to ensure that they are minimised. This involves the use of UV and heat stabilised materials or the use of screening methods.

A portion of the electromagnetic spectrum is represented schematically in Figure 1 and shows large UV and infrared portions. However the damage to luminaires from UV radiation is caused by only a narrow band. This is because of atmospheric absorption in the case of solar radiation and absorption by the lamp envelopes. Typical UV levels emitted by various light sources are shown in Figure 2. The UV content of daylight is also included but care should be taken when making comparisons.

Fig 1: **Part of the electromagnetic spectrum. UV and infrared radiation are invisible but make up a large part of the spectrum. Sunlight, after absorption in the atmosphere, contains only a small portion of these types of radiation (290-1700nm) but, nevertheless, can still do considerable damage to luminaires.**

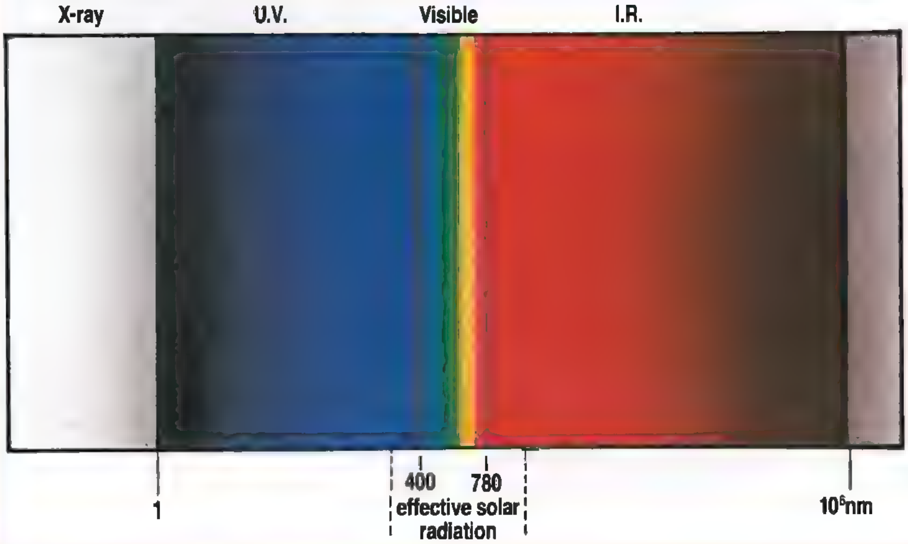


Fig 2: **The UV emission from various light sources and daylight.**

Lamp Type	Ultra Violet Emission (MW Per 1000 Lumen) UV(A) (400-315nm)	(UV(B) (315-280nm)	Light Output (Lumen)
High pressure mercury (MBF) 125	547	5	5,800
Low pressure mercury fluorescent (MCF) warm white 125W	78	18	8,800
"Natural" 125W	123	5	6,500
Domestic light bulb GLS 40W	45	–	400
High pressure sodium (SON) 70W	37	3	5 300
Compact fluorescent 2D 16W	66	–	925
Daylight (6500 °K)	486	54	–

At the top of the page is the UV discharge rig. Plastic materials are aged under UV. The curved support plate provides thermal acceleration. Pictured right is the salt spray test apparatus where accelerated corrosion testing is carried out. Care must be taken in interpreting the results which are obtained under steady, continuous conditions. This is rarely the situation in practice except perhaps under immersion conditions.

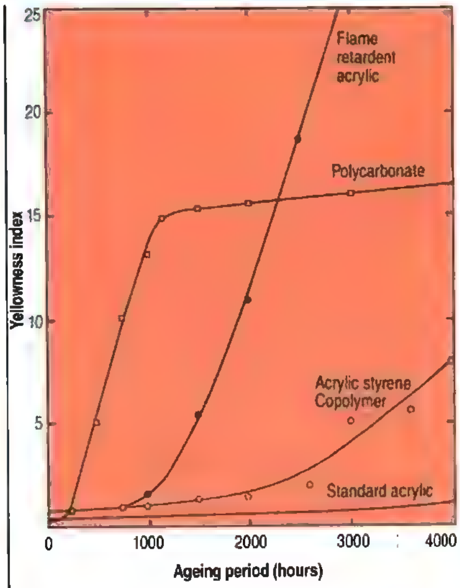


Fig 3: **Yellowness Index Change for polycarbonate and various acrylics. Acrylic plastics have the greatest resistance to degradation under UV irradiation. However, when these materials are modified eg, to improve flame resistance or to reduce cost, the penalty is a loss in UV stability.**

UV TEST (DISCHARGE RIG)

The test used at the Enfield Laboratories to simulate UV attack was developed after extensive trials and utilises a 400 watt mercury discharge source. Other sources such as a mercury arc within a quartz envelope were found to be too severe, making it difficult to distinguish between relatively stable and distinctly unstable plastics. Although the 400W MB/U source does not simulate the solar spectrum, which is continuous, it gives a good indication of the relative stabilities of the plastics involved. The actual apparatus used comprises a heated plate, mounted concentrically with the lamp axis.

Typical results obtained for acrylic and polycarbonate, aged in this apparatus, are shown in Figure 3. The "Yellowness Index" is obtained from spectral transmission data and represents the colour shift in the materials according to the "CIE Chromaticity Diagram". This index only indicates a "cosmetic change" and does not relate to changes in mechanical properties. In many applications the latter is more significant and would therefore be monitored with a suitable test. The change in impact strength with ageing, is of particular importance where vandal resistance is of concern eg, prison cell lighting. Whilst polycarbonate exhibits exceptional toughness when compared with most diffuser materials, the effects of ageing can be quite dramatic. In samples tested the material was still "cosmetically" acceptable after the full ageing period but its impact strength was reduced to the level of toughened acrylics.

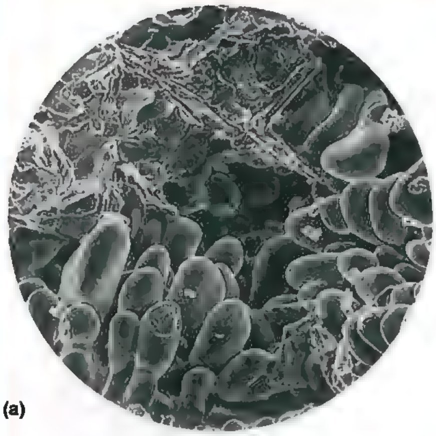
One interesting fact about "yellowing" in plastic diffusers is that it only marginally reduces light output ratios.

CORROSION

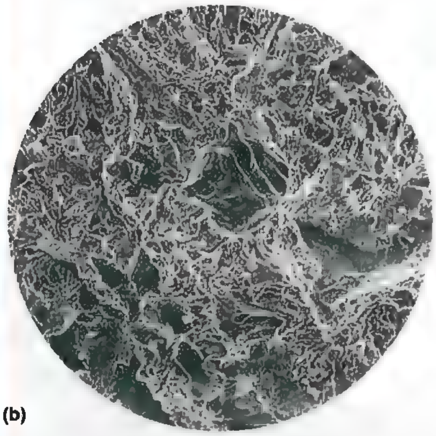
This is a more familiar form of breakdown but it can take many forms including rusting or deterioration of metallic components, paint flaking, seizure of fixing screws or hinges, reflector tarnishing through moisture-borne salts and debris etc. Corrosion mechanisms are normally electrolytic but in some cases conjoint action involving stress may occur. Where paint films are present these may be the cause of substrate corrosion or may themselves blister as a result of substrate corrosion. Nowadays, glass reinforced plastics (GRP) are commonly used in exterior environments or areas of high humidity to combat the effects of corrosion but for certain applications metals are essential because of the temperatures involved eg, floodlighting. Whilst resisting corrosion, GRP materials may be subject to chemical action which is discussed later.

SALT SPRAY TESTS

A special chamber is utilised for accelerated corrosion testing. Essentially, it consists of a controlled temperature environment in which a corrosive mist, usually based on sodium chloride, is produced. Specimens, which can consist of painted panels, alloys, galvanic couples etc are placed on plastic racks or suspended within the mist for selected periods. The corrosion of commonly used aluminium alloys has been studied using this apparatus. LM6 is an aluminium silicon alloy that could be used in many exterior applications without a paint film for two reasons. Firstly, it has a low rate of corrosion. Secondly and more importantly, attack on this alloy is uniform. LM2 and LM24 both contain small quantities of copper and this tends to encourage pitting attack and therefore results in a more unpredictable corrosion performance in the field. However, although LM6 is used externally for luminaire bodies etc, it is still painted, for cosmetic reasons. The perform-

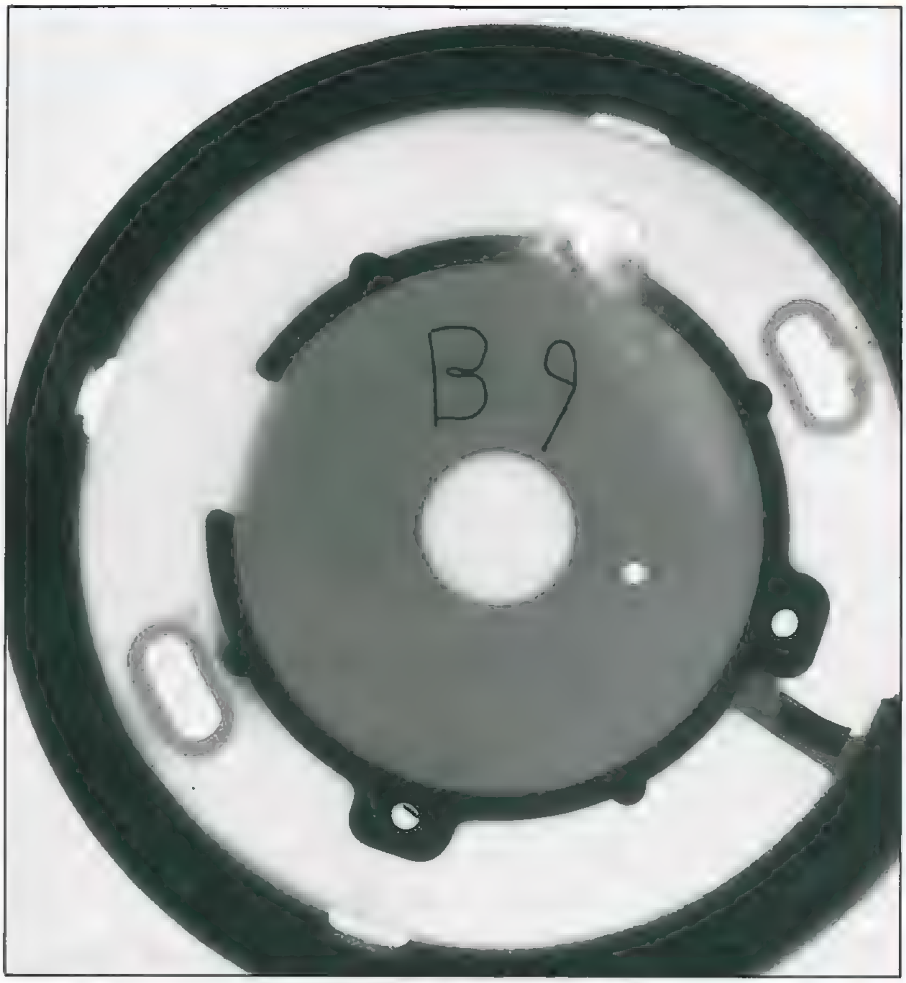


(a)



(b)

Scanning electron micrographs of aluminium fracture surfaces. Coarse aluminium dendrites (a) result in a weak alloy which is riddled with fine porosity. The fracture surface (b) indicates a much finer structure and is preferable where strengths and corrosion resistance are important.



The use of X-rays is a useful non-destructive method of assessing the soundness of castings. Pictured is an X-ray image of an airfield inset luminaire. The boss above the 'B9' marker shows considerable porosity. Corrosive elements in this field could easily penetrate these weak areas especially if the porosity is near the surface.

ance of any casting alloy can be affected by the soundness of the product or impurity level. These factors can easily be checked by X-rays or by metallurgical techniques including scanning electron microscopy.

Care must be taken in using salt spray data for predicting field performance because of the many variables in the environment which cannot easily be simulated in a salt spray rig. An example of this is shown in Figure 4 where the performance of bimetallic contacts in marine, industrial and rural environments is represented schematically. Steel is normally anodic to aluminium and therefore usually corrodes perferentially. However, this would not be predicted by the salt spray data which would give the opposite result due to polarity reversal. The salt spray data is therefore only valid for a marine environment in this instance. The reason for this apparent anomaly is that the protective oxide coating on aluminium is broken down by the chloride ions. It should be noted that the rates of corrosion of all these metals will be reduced by the incorporation of a "corrosion barrier" or the use of an "inhibiting paste". These are frequently used where stainless steel fasteners are in contact with aluminium alloys.

CHEMICAL DEGRADATION

This is an extension of corrosion and affects most plastics and rubbers. The results can include softening, swelling, shrinkage, embrittlement, dissolution, crazing, fracture etc. In GRP materials delamination is a common breakdown mode which can also result from UV attack. Accurate information on environmental conditions at an installation is required if a lighting scheme is to be successful in a chemically active environment but, all too often, this is not available or cannot be supplied.

A further complication is that many plastics will only be attacked in a particular environment if they are under stress at the same time. This can be moulded-in during fabrication or introduced by the design or fixing method. Where both the environment and stress are involved, the attack is known as "Environmental Stress Crazing" but it can lead to more catastrophic effects than simple crazing. The analogy in metals is "stress corrosion cracking", which can cause unexpected fractures of pipes, impeller blades etc. Thus where plastics are concerned chemical tests are usually carried out with and without additional applied stresses.

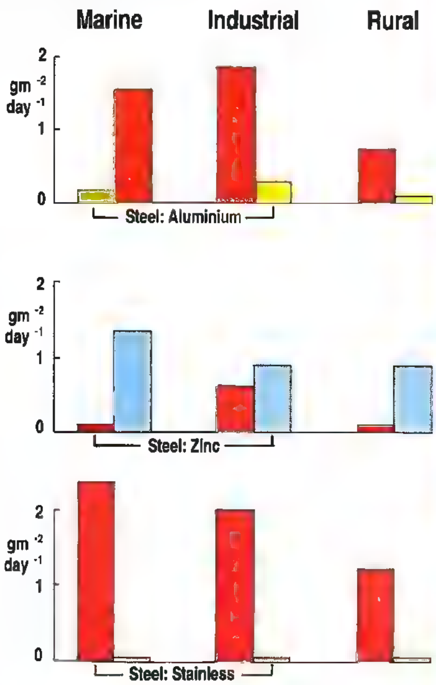


Fig 4: **Corrosion rates for joined metal couples in various atmospheres. Whilst salt spray data can usually be related to most materials and environments, there are a number of exceptions eg, the polarity reversal exhibited by the Al/Fe couple would not be predicted. NB: The corrosion rates of the steel, zinc and aluminium would be reduced considerably if the metals were corroding separately.**

Illustrated above are strain patterns of various moulded plastics. A plastic (or glass) viewed between crossed polarisers will reveal coloured fringes which represent the level of stress in that material. In general, the greater the number of fringes, the higher the stress level. Facing this, is a poorly maintained floodlight. Both glass and reflector surfaces have been adversely affected by breakdown of the gasket, ingress of moisture and dirt.

CHEMICAL TESTS

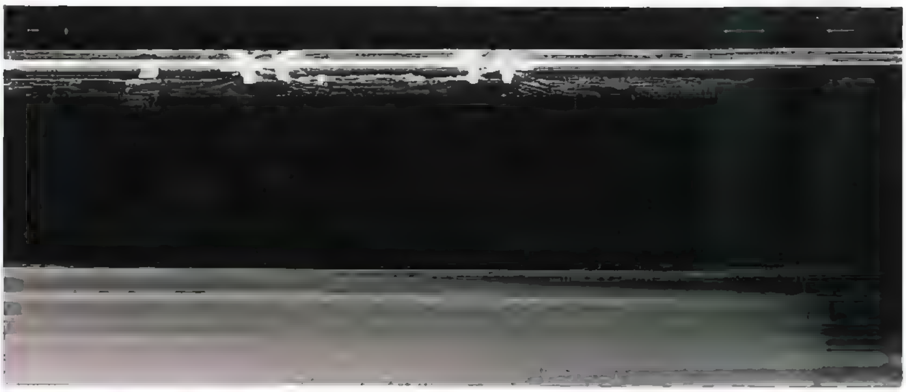
The simplest test to identify a problem is to immerse a sample of the material in the chemical concerned. However, the more common method is to suspend samples above the liquid so that they are under attack from its vapours. This is closer to reality and is analogous to the salt spray test already described. Many materials would remain unaffected in the latter configuration and yet deteriorate rapidly by full immersion. Conditions in both methods can be varied by concentration and temperature changes.

The effect of stress has already been mentioned and this is by far the most common cause of breakdown in a chemical environment. In plastics such as polycarbonate, acrylic and polystyrene "stress crazing susceptibility" can be assessed by applying the appropriate chemical to the stressed area and observing the effects. For polycarbonate, the toluene-n-propanol test (TNP) is used. A 1 in 3 mixture will cause crazing within three minutes if stresses exceed 10 MNm-2. Different concentrations may be used for different stress levels. Whilst every effort is made to avoid this type of attack, in practice it is difficult to eliminate unless the stress in the component is removed entirely. Acrylic, for example, has even been known to "stress craze" in the presence of moisture.

DETERIORATION THROUGH POOR MAINTENANCE

The tests described so far will only result in a reliable product providing sufficient care is taken of the luminaire during its lifetime. This implies regular maintenance and fortunately this is an area that is now receiving more attention eg, certain luminaires are now available with self-cleaning reflectors. The collection of dust and insects in non-proof luminaires is well known and usually results in a reduction in light output and a loss of control. These factors are often reversible.

However, the ingress of debris can also occur in proof luminaires as a result of the failures of a component such as a gasket or as a result of vacuum effects when the luminaires are switched off. The floodlight illustrated is an extreme case where no maintenance was involved over a period of approximately five years. The ingress of dirt and moisture occurred because of the breakdown of the unscreened silicone gasket by the UV radiated from the lamp and has dramatically affected the performance. However, a restoration to the original performance level would only be achieved by changing the reflector and glass — actions which would not have been necessary if a simple maintenance schedule had been followed. Screening of the gasket would minimise the risk of recurrence.



The fractures in this acrylic bowl are the result of high stress levels in the assembly and the nature of the environment. Individually, the two factors would have no effect.

CONCLUSIONS

The importance of good maintenance cannot be over emphasised since without it, the full benefits of thorough testing and appraisal will not be realised. It has only been possible to outline some of the background work that is involved in ensuring that product standards are maintained. Nevertheless, the reader should have gained an insight into an area that is so often overlooked or taken for granted.

Above: Lighting Newport Leisure Centre's indoor pool required careful consideration of safety and glare for swimmer, attendant and spectator alike. General lighting of the irregular shaped main pool is achieved by 40 wall mounted floodlights, using 400W SONDL elliptical and tubular lamps. Average horizontal illuminance across the water surface is 546 lux while half of the floods use black transverse louvres to minimise direct glare. Wall washing of the fascia brickwork enclosing the pool is met by 32 IP54 rated 200W linear tungsten halogen floodlights. Additionally, decorative pool colour effects are provided by 500W tungsten halogen spotlights and 14 underwater luminaires employing 400W MBIF mercury Kolorarc lamps. A sophisticated switching and control arrangement operates.

Left: Liverpool's international library, containing over 100,000 books, has been relit with specials. The unusual combination of SONDL and fluorescent lamps has virtually quadrupled the illumination whilst reducing electrical load from 14.5 to 11kW. Eight specially shaped, glass reinforced gypsum uplights, each housing two 250W SONDL lamps, have been suspended from the ceiling by steel rods. The units are equipped with removable gear trays for easy maintenance. Due to the tiered nature of the circular library additional lighting was necessary to avoid shadowing. Twenty one special 3600mm fluorescent fittings, each housing four 1800mm Polylux 3000 lamps with low glare batwing louvres were therefore selected for the circumference areas. The scheme produces a vertical lighting level of 150 lux over the bookshelves. The previous installation of 112 tungsten ballasted 1200mm 40W and eight 2400mm 125W fluorescents gave only 40 lux.

IAIN MACLEAN

Meeting the growing need for specials

The needs of most lighting projects can be met by many manufacturers who offer products from standard ranges, yet the market for 'tailored' fittings and schemes is thriving. This is because the requirements for building services are becoming more sophisticated, requiring ever closer integration of lighting with other aspects of environmental control, and also as the desire of individual architects and interior designers to stamp their individuality on the buildings they design has increased.

This article looks at made to order lighting projects from a supplier's viewpoint; to provide readers with both an insight into this type of work and with pointers to possible future solutions.

SMALL IS BEAUTIFUL

Small lighting companies react to the demand for 'specials' by concentrating on the production of made to order designs. Such companies often rely on low volume non-repeat production and emphasise a personal relationship with their customers, which includes provision of the necessary specialist advice.

LARGE IS RESOURCEFUL

There was an inevitable tendency for the large lighting companies to be less flexible. In theory, it is difficult to achieve low unit prices for specials when they are developed using the full techniques and procedures applying to the development of standard products which will be manufactured in hundreds of thousands. The very strengths which help secure the standards' market can be a drawback in the specials' domain.

On the other hand, the large companies do have unrivalled resources of research, development and manufacturing expertise, fully professional management and sound finance. What has been lacking is some way to combine the nimbleness and flexibility of the small man with the muscle of the large manufacturer.

Mr Maclean is Project Co-ordination Manager, Special Projects Group of THORN EMI Lighting at Enfield.

A SUCCESSFUL OUTCOME

THORN EMI Lighting has taken a lead by forming a Special Projects Group. Based at the Jules Thorn Laboratories at Enfield, the Group's role is to react quickly to specifiers' needs for specials by applying the right combination of skills from the engineering 'pool' while abbreviating inappropriate standard procedures. Demonstrably, specials can be engineered to high standards of quality and performance without so much attention to the finer points of mass production and international standards conformity which would be necessary for stock items. Procedures can be shortened without the loss of expertise embodied in the Company's standard products. Thus the benefits of a large organisation can be added to the flexibility of a small, distinct unit.

CO-ORDINATION REQUIRED

The Special Projects group exists to co-ordinate all facets of design and manufacture, from the basic lighting requirements through to integration of the final product with other building services – an aspect calling for a full understanding of heating, ventilation control and ceiling systems.

Three recent projects illustrate the role and success of the Special Projects Groups.

CASE STUDY 1: STEWARTS SUPERMARKETS

A particularly innovative approach at Stewarts Supermarket in Northern Ireland was to use high intensity discharge light sources to improve appearance whilst economising on electricity, so that the traditional supermarket lighting scheme – continuous rows of surface mounted multi-lamp batten luminaires – is nowadays not the only option.

Originally Stewarts experimented with high intensity discharge light

Stewarts Supermarkets at Connswater in Northern Ireland using unusual inverted-pyramid shaped uplights.

sources in downlight style fittings, but the highly directional nature of the light provided insufficient vertical illuminance. Lack of light penetration to the rear of gondola shelving was also a problem and any lamp failure left a comparatively large area of the store under lit.

The solution for the store at Connswater consisted of special inverted pyramid shaped pendant uplights that 'float' below the ceiling like geometric clouds.

Early photometric calculations established likely wattages and Special Projects Group designers submitted sketch proposals illustrating the cosmetic arrangements that would best complement the vaulted ceiling. The final scheme uses 119 pyramid uplighters suspended over the supermarket floor area and 28 half pyramids secured to perimeter walls. These have de luxe high pressure sodium lamps of 400W and 150W respectively providing a 720 lux lighting level for the modest total load of 56.8kW. Taking the 2680m^2 floor area, this equates to an efficiency of 34 lux per W/m^2.

The uplight fittings were manufactured in glass reinforced gypsum, combining good appearance with several advantages over steel — including its lower expense and its ability to be readily formed into precise geometric shapes without distortion.

A spin-off from this work is that the marketing department, sensing wider market potential for the special uplight fitting, later derived standard designs from it and have introduced these as stock items.

CASE STUDY 2:
W H SMITH AND SONS

Stationer W H Smith required an increase in air handling capacity at certain times of year from the integrated Arena 2 linear fluorescent fittings installed at its Preston store. The laboratories designed the higher volume air handling grille to fully integrate with the Arena 2 system while providing the necessary high performance. Laboratory tests on a prototype showed full compliance with air volume, air envelope and noise specifications. The Special Projects Group engineer responsible for coordination throughout the programme went on to liaise with on-site contractors to ensure trouble-free installation of the modified fittings. Finally a detailed site survey satisfied all parties that the design criteria had been met fully.

Above is W H Smith, the stationers and booksellers store at Dewsbury using the Arena 2 lighting system with integrated emergency lighting. On the right over 2,000 highly efficient Polylux 3500 fluorescent lamps in special recessed air handling luminaires with low brightness reflectors, provide a high level of visual comfort for Townsend Thoresen staff at Dover. Lighting levels of 600 lux in individual offices and 700 lux in open plan areas have been achieved.

The novel refurbishment from tungsten to sodium pendants at Rickmansworth Masonic School is illustrated at the top of the page. Below right is a view of Sociedade Portuguesa de Investimentos's Lisbon offices in Portugal. Special uplights have been installed.

'Standard' Arena 1 and Arena 2 fittings themselves evolved as standard products from special one-off designs. In the early 1970s Arena 1 pioneered the integration of several of the ceiling mounted building service components such as luminaries, air diffusers and sprinklers. The system had grown directly from several special projects for which a high level of integration was required.

As the market has evolved, new lamps, control gear and optional systems were developed and the improved Arena 2 came into being. W H Smith was one of the first customers to use Arena 2 to improve standards of lighting and thermal comfort in its premises.

CASE STUDY 3: RICKMANSWORTH MASONIC SCHOOL

An unusual lighting approach transformed an outdated tungsten lighting scheme in the Great Hall of Rickmansworth Masonic School.

An energy survey showed that their existing scheme, although in keeping with the 1934 decor, was very inefficient. The existing lighting of seven 100W tungsten filament lamps per fitting provided an illuminance of only 30 lux – totally inadequate for activities ranging from academic examinations to badminton. It also posed a maintenance headache, the rather inaccessible lamps requiring frequent changes and cleaning.

The Special Projects Group proposed re-use of 14 existing pendant fittings forming part of the original 1934 decor. Arrangements were therefore made to remove the pendants for conversion to accommodate two 250W de luxe high pressure sodium lamps with remote control gear. The result – ten times the illumination, with vastly improved brightness of decor, electrical load reduced from 9.8 to 7.75kW and maintenance greatly reduced. Following the success of this conversion, work is now proceeding to update lighting standards throughout the rest of the school premises with the wide use of 2D lamps and luminaires.

FROM START TO FINISH

Such examples illustrate the role of the Special Projects Group in seeing a lighting scheme through right from initial advice and concept, to installation and integration of custom produced specials. A small, tightly knit group is better equipped to combine commonsense and flair with technical skills to produce satisfying results. Allocation of one responsible engineer provides the continuity to ensure a timely and successful outcome. In one recent example Newport Borough Council (South Wales) were delighted to deal with a single engineer on aspects of lighting for its new Newport Leisure Centre, from inception through design to installation and final aiming of the floodlights on site.

CONCLUDING THOUGHTS

The elaboration of building services within a premises is likely to develop further rather than diminish as is the standard of architectural design. All these factors will lead to a constantly changing demand for specialist product and technical design. Looking into the future, one could venture the prediction that the work of the Special Projects Group will become ever more involved and important.

PAT HOLLEY

Lighting the Hong Kong Coliseum

Modern Hong Kong is making exciting and rewarding contributions to quality architecture. The Hong Kong Coliseum is just such a building. Situated on the waterfront of Kowloon Bay it incorporates high standards of design, technology and materials, combined with a novel attitude towards development. The architectural ingredient that makes this building so spectacular is its inverted pyramid structure, built on top of the Hung Hom railway station. It has a seating capacity of 12,500 people and is one of the largest and best equipped indoor stadia in the world. It provides an international venue for cultural activities, ice spectaculars, professional sports, conventions and trade exhibitions.

CONSTRUCTIONAL CONSIDERATION

The railway tracks beneath the stadium formed the major structural constraint to the design: the inverted pyramid design permits the use of a limited number of supports carried down to caisson foundations below. Unlike most buildings, construction began with the roof, 24m above floor level, and progressed down.

Mr Holley is Assistant Manager International Project Engineers' Department of THORN EMI Lighting at Romford.

THE LIGHTING SPECIFICATION

Theatres, exhibition halls, indoor sports arenas and ice rinks all have different lighting needs, so designing a lighting system for the multi-purpose arena required some resourcefulness. The solution consists of 220 strategically placed floodlights with a potential electrical load of 298kW. To meet the diverse lighting requirements a six level switching arrangement has been installed (see Table 1) which is remotely controlled. The high illuminances required for settings 3 through to 6 demanded the use of high intensity discharge (HID) lamps with good colour rendering. Settings 1 and 2 required tungsten halogen lamps with instant restrike capabilities for general house lighting before and during theatrical performances, and during the run up period for the HID light sources.

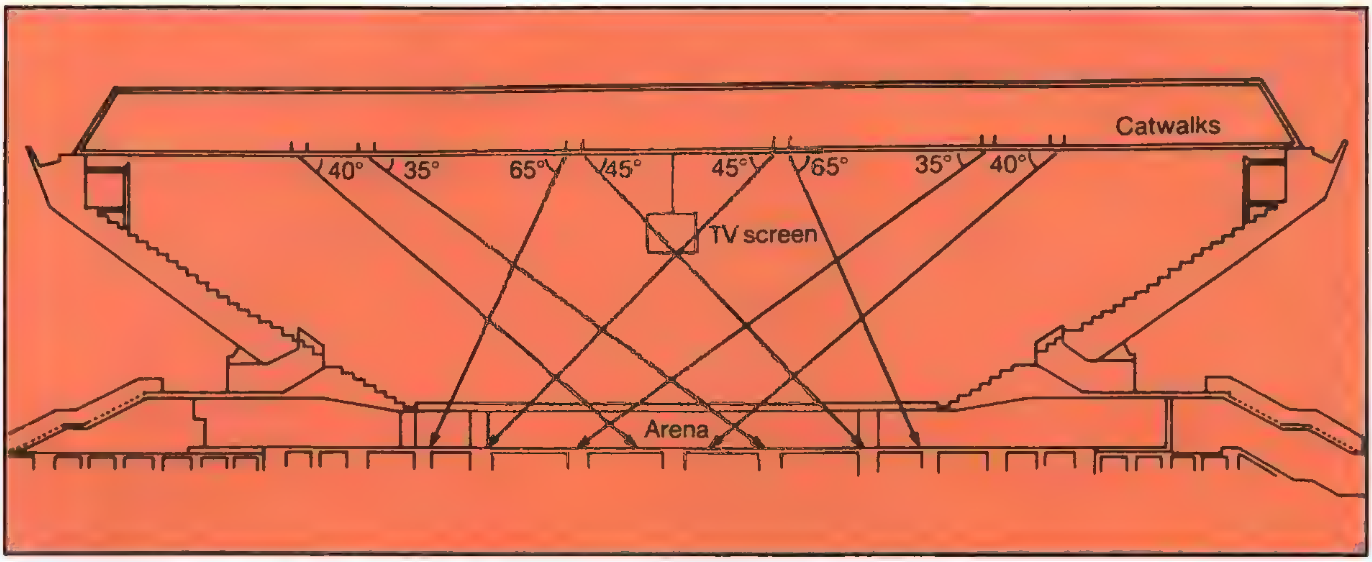
Switching arrangement	Specified average horizontal illuminance (lux)	Recommended for
1	100	Theatrical performance
2	200	Badminton (recreational) exhibitions; shuffleboard; theatrical performance; volleyball (recreational)
3	360	Badminton (tournament); basketball (recreational); exhibition; fencing (recreational); roller skating; table tennis (recreational); volleyball (tournament)
4	570	Basketball (tournament); fencing (tournament); gymnastics; table tennis (tournament)
5	700	Ice spectaculars; indoor tennis (tournament); roller skating (professional)
6	1600	Colour television broadcasting for all activities

Table 1: **Lighting provided for the various activities.**

PROBLEMS OF MOUNTING

The major obstacle to any lighting scheme is the fixed location of the floodlights. Extreme care and attention was needed to ensure that all vertical surfaces were properly illuminated for

The previous page shows the impressive exterior of the Coliseum, and above, the giant television display screen which complicated the lighting scheme.



Section of the Coliseum, showing the relationship of the floodlights to the arena. Principal aiming angles are given.

colour television broadcasts, while spectators and players could follow the trajectories of tennis, basket and volley balls, and shuttlecocks, without experiencing problems from glare. To aggravate the situation further, the arena houses a giant, (5.1m x 3m) centrally suspended, four faced television projection screen and electronic scoreboard, the height of which varies above the arena floor depending upon sporting functions. The floodlights had to be positioned and aimed so that excess spill light did not fall onto the screen, which would wash out the projected picture. With these conflicting requirements, a certain amount of compromise had to be accepted. The manufacturers of the television projection system advised that a maximum spill illuminance of 200 lux could be allowed to fall on the screen at any point, any more would result in an unacceptable loss of definition.

The ceiling void has a network of catwalks at a roof truss height of 23.1m for servicing air conditioning plant. These provided suitable locations for the mounting of floodlights.

ILLUMINANCE CALCULATIONS

Spectator viewing takes place from four sides of the stadium and the lighting system is designed to provide similar viewing conditions from each direction. To determine accurately the number of floodlights required for each switch position, preliminary hand calculations were checked by a floodlighting computer program. With all the floodlighting positions and angles determined, the final calculation checks were made to ensure adequate illuminance on the spectator areas for colour television transmissions and that the spill light falling onto the TV projection screen was within the specified limits. The average vertical illuminance due to direct and indirect light falling on the screen was calculated to be 163 lux (64 lux indirect).

THE LUMINAIRES

The HID floodlight selected for the switch positions of settings 3, 4, 5 and 6 was the ON1500 unit which utilises the 1500W MBIL un-jacketed doubled ended metal halide lamp (the floodlight acts as the outer envelope for the lamp). The correlated colour temperature of this light source is 4500K, giving good cool-white colour rendering, ideal for television coverage. This combination of fitting and lamp gives a wide fan shaped horizontal beam and an asymmetric vertical light distribution with a sharp cut-off above the peak intensity. An internal baffle is incorporated to help reduce glare. Although the floodlights have very good vertical beam control, it was necessary for 72 floodlights used on the 6th switch position to employ deep louvre attachments to further restrict the amount of spill light falling onto the projection screens.

Wide horizontal angle asymmetric vertical distribution OHS1000 floodlights with 750W linear tungsten halogen lamps were selected for switch positions 1 and 2. For setting 4, a combination of tungsten halogen and metal halide was used. The seating area lighting also used tungsten halogen floodlights but with a diffused light distribution and 1kW lamps. The total quantities and final distribution of floodlights per switching sequence is given in Table 2.

Number	Type	Electrical Load (kW)
First switch		
36	OHS 1000/750 W THD	27
Second switch		
64	OHS 1000/750 W THD	48
Third switch		
14	ON 1500/1500 W MBIL/H	
8	ON 1500/ONR/1500 W MBIL/H	35
Fourth switch (2nd and 3rd switches)		
64	OHS 1000/750 W THD	
14	ON 1500/1500 W MBIL/H	
8	ON 1500/ONR/1500 W MBIL/H	83
Fifth switch		
28	ON 1500/1500 W MBIL/H	
16	ON 1500/ONR/1500 W MBIL/H	70
Sixth switch		
28	ON 1500/1500 W MBIL/H	
56	ON 1500/ONR/1500 W MBIL/H	
72	ON 1500/with louvre/1500 W MBIL/H	248

Table 2: **Floodlighting quantities and electrical loading per switching sequence for arena.**

The spectacular view of the arena from the control centre.

ELECTRICAL SERVICES AND LIGHTING CONTROL

The roof truss level floodlights obtain their power from the main switchboard. A plug-in busbar trunking is installed in the form of a closed ring for flexibility and future extension. The control gear to operate the metal halide lamps is mounted adjacent to the floodlight, the final connection into the unit from the control gear box being made with flexible conduit.

The lighting control circuits are so arranged that when the metal halide floodlights are switched on, the tungsten halogen lamps are automatically switched on for the first ten minutes. To minimise a starting surge at the highest lighting levels, time delays were incorporated into the control circuit so three banks of metal halide floodlights will be switched on one at a time.

In case of normal power failure, the essential arena and seating lighting would be switched on and kept supplied from the 200 kVA emergency diesel generator.

The lighting control console and operator are positioned high up in a room overlooking the arena and seating areas.

ACKNOWLEDGEMENTS

The project was designed by the Architects' office of the Hong Kong Government's Public Works Department.

The combination of technical expertise offered by THORN EMI, with the close collaboration of building services engineers J Roger Preston & Partners, has led to the completion of this prestigious building. Certainly, as the Coliseum shows, Hong Kong is now setting a new style of high technology city buildings.

Interesting Worldwide Installations

Here we examine seven different aspects of THORN EMI Lighting's worldwide activities. Yet a common theme runs through them all — the use of modern, compact, energy efficient light sources.

Top left: Hewlett Packard's factory at Stoke Gifford, Bristol. The manufacture of computer tape and disc drives required precise, economical control of light, combined with a careful balance of heat. It was decided to use air handling luminaires using four 36W 1200mm triphosphor fluorescent tubes with de luxe colour rendering properties and batwing louvre attachments. A total of 912 recessed luminaires provides a service illuminance of 850 lux for an installed load of 167.8kW, a target efficiency of 53 lux per W/m^2. The luminaires around the perimeter of the factory are photocell controlled with the remaining lighting linked to a central energy management system.

Top right: Radpak luminaires with SONDL-T lamps have been installed in THORN EMI Domestic Appliances' Spennymoor factory. The radial batwing distribution provided is ideal for symmetrical spacing, enabling uniform lighting with good glare control and correct vertical illuminance to be achieved.

Bottom left: A modern indoor garden centre in Unna, Germany. Twenty four low bay luminaires using horizontally mounted 250W SONDL-T lamps were selected. The batwing distribution provides good uniformity of illuminance at wide spacings while the warm golden white light source achieves a pleasant sales atmosphere.

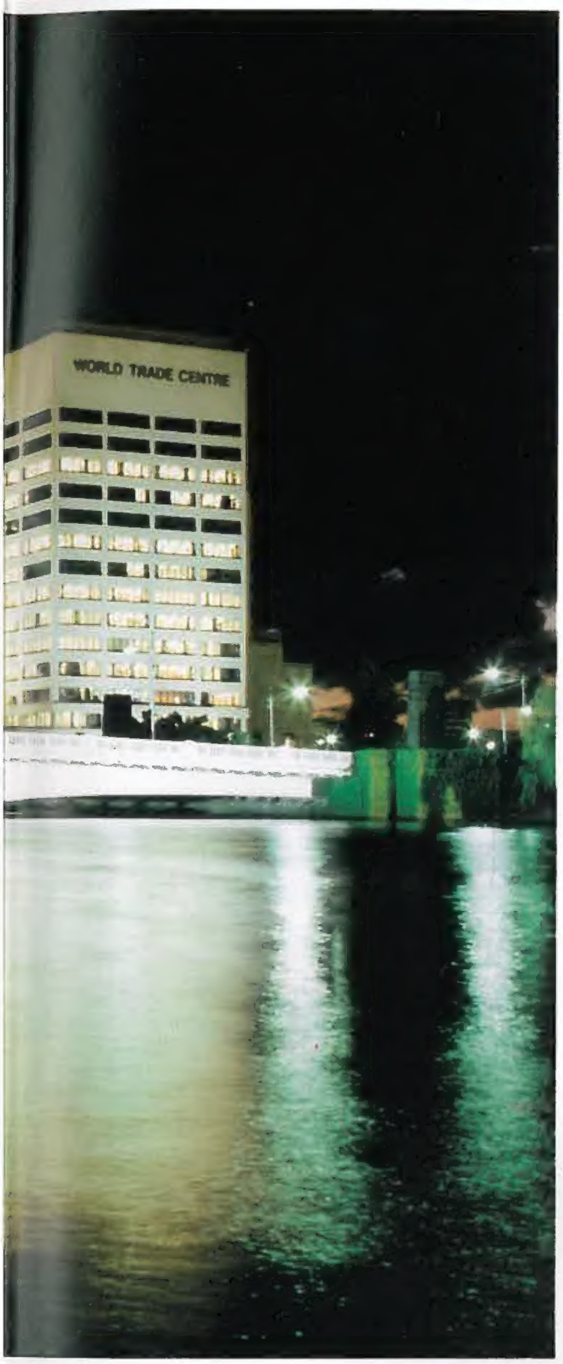
Bottom right: The Welsh Rugby Union National Stadium (Cardiff Arms Park) has become the world's first rugby stadium to be floodlit using linear metal halide floodlights and MK Electric's industrial sockets and plugs. Intended for training purposes, an illumination level of over 200 lux between posts is achieved. The units used are ON1500 fittings, with 1500W lamps giving excellent colour rendering and low glare. The design of the stadium has made it possible to use the 'side lighting' technique, with a total of 36 floods (18 per side) mounted along the stand roof (See inset). To attain even light distribution 12 of the floodlights have special dispersive reflectors to give a wider beam angle and a shorter throw.

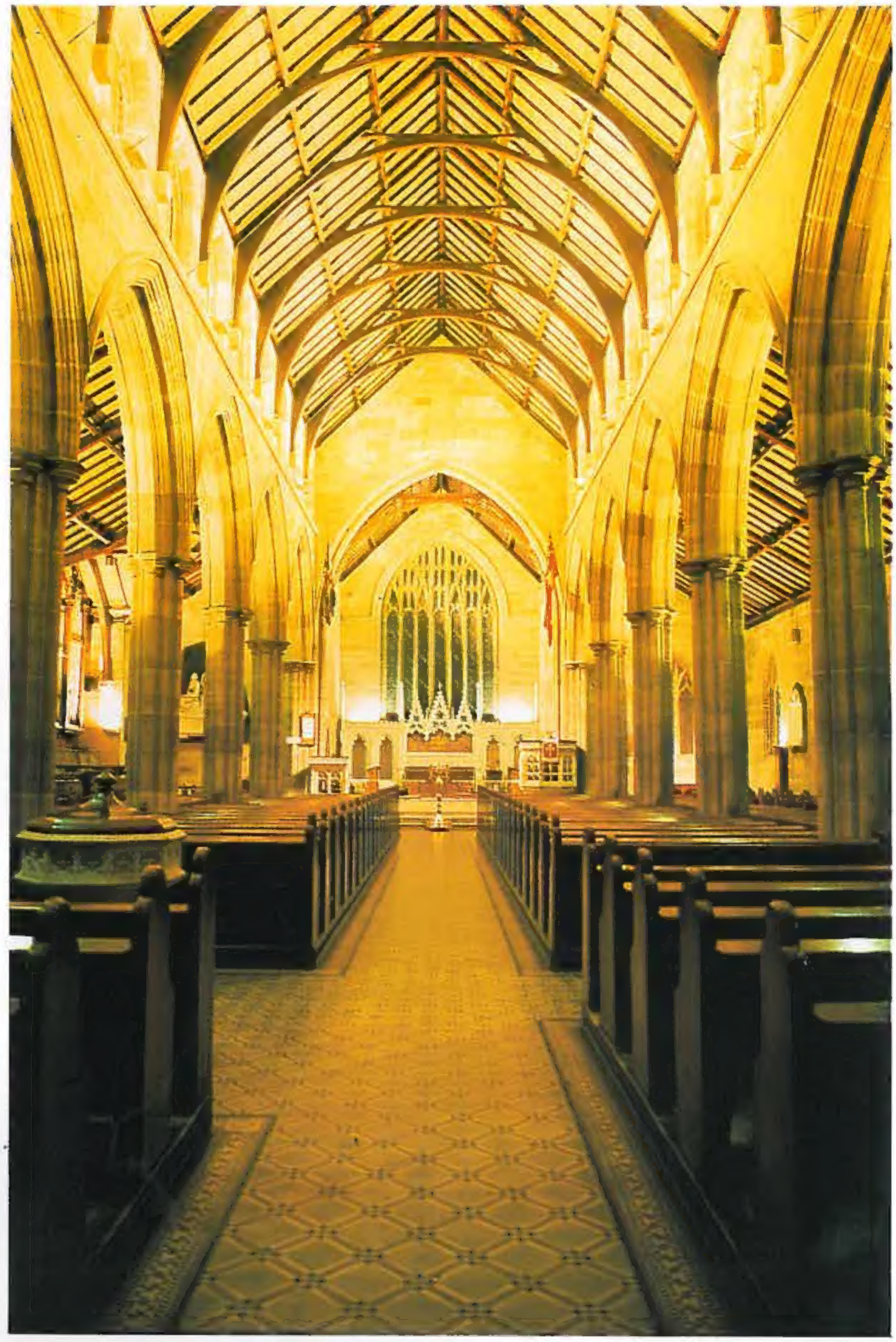
Above: At Melbourne in Australia, the Spencer Street Bridge has been strikingly floodlit by metal halide lamps.

Above right: The magnificent St Philips Church, Sydney, Australia has received the high pressure sodium lighting treatment.

Below right: The 11,000m² Tipshallen sports complex at Jönköping in Sweden has a capacity to seat up to 4,000 spectators. Built to stage indoor football games during the winter and provide a venue for cultural activities in the summer months it has been lit throughout with SON. The exterior features 250W SONPAKs while indoors 133 luminaires housing twin 400W SONDL-T lamps are used.

Below left: Grundy Production's "It's a Knock Out" television game show in Sydney, Australia using two hundred and twenty 1kW CSI floodlights. Note the foreground area, part of the main field, is lit with only a small amount of spill light. Lighting is directed at areas where the events are to be played, the floods being redirected prior to recording to suit the individual game requirements, thus maximising light for TV coverage. A minimum of 800 lux on all vertical surfaces, 1m above the ground is achieved, although over 2500 lux is possible for the main camera directions. The lighting is arranged in a non symmetrical layout over 6 poles. Interchangeable lenses allow beam distributions from 6° to 60°.


WORLD TRADE CENTRE




Elmia
Tipshallen
1X2

THORN EMI Lighting Ltd

UK Regional Sales Offices and Showrooms

Belfast
Prince Regent Road, Castlereagh
Belfast BT5 6QR
Telephone 0232-794122
Telex 74695 TLLBft G
Birmingham
Thorn House, Aston Church Road
Saltley Trading Estate
Birmingham B8 1BE
Telephone 021-327 1535
Telex 337435 TLLBhm G
Cardiff
Thorn House, Penarth Road
Cardiff, Wales CF1 7YP
Telephone 0222-44200
Telex 498334 TLLCdf G
Leeds
Thorn House, 3 Ring Road
Lower Wortley, Leeds LS12 6EJ
Telephone 0532-636321
Telex 55110 TLLLds G
London North Sales Office
Huntsman House
Ferry Lane
Tottenham
London N17 9NF
Telephone 01-801 8191
London South Sales Office
Victoria Trading Estate, Victoria Way
Charlton, London SE7 7PA
Telephone 01-858 3281
Telex 896171 TLLChn G
London Showroom (opens Summer 1986)
Suite 330
The Business Design Centre
Upper Street
Islington Green
London N1 0QH
Telephone 01-288 2330
Manchester
Thorn House, 2 Claytonbrook Road
Clayton, Manchester M11 1BP
Telephone 061-223 1322
Telex 668642 TLLMcr G
Scotland
Thorn House, Industrial Estate
Larkhall, Lanarkshire ML9 2PA
Telephone 0698 886007
Telex 777930 TLLLkh G

Government Contracts & Order Office
284 Southbury Road, Enfield
Middlesex, EN1 1TJ
Telephone 01-363 5353
Telex 263201 THORN G TOTLG

Head Office
284 Southbury Road, Enfield
Middlesex, EN1 1TJ
Telephone 01-363 5353
Telex 263201 THORN G TOTLG

THORN EMI Lighting Ltd
Overseas Companies

European Subsidiaries Head Office
284 Southbury Road
Enfield, Middlesex EN1 1TJ
Telephone 01-363 5353
Telex 263201 THORN G TOTLG
Subsidiaries in:
Austria, Denmark, France, Germany, Ireland, Italy, Norway, and Sweden. Distribution in Belgium, Holland and Switzerland.

Direct Exports Head Office
PO Box 18, 3 King George Close
Eastern Avenue West, Romford
Essex RM7 7PP
Telephone 0708 66033
Telex 897759 THLITE G
Cables Thornlite Rford

Subsidiaries in:
Australia, Canada, New Zealand and South Africa.

Australia
THORN EMI Lighting
210 Silverwater Road, Lidcombe
New South Wales 2141
Telephone 648-8000
Telex 22350 Thornlit Sydney
Austria
THORN EMI Licht GmbH
Erzherzog-Karl-Strasse 57, 1220 Wien
Telephone 0222 23 35 71
Telex 136128 THOR WA
Canada
THORN EMI Lighting Canada Limited
1400 Meyerside Drive, Mississauga
Ontario L5T 1H2
Telephone (416) 677-4248
Telex 06-968569
Denmark
THORN EMI Belysning A/S
Brogrenen 6
DK-2635 Ishøj
Telephone (02) 54 06 77
Telex 33197 KENWD DK
France
THORN EMI Eclairage s,a
61 Rue Emile Zola
69150 Decines
Telephone 078498112
Telex 380900 THORN F
Germany
THORN EMI Licht GMBH
Möhnestrasse 55, Postfach 2580
5760 Arnsberg 1
Telephone 02 932 2050
Telex 847166 THORN D
Ireland
THORN EMI Lighting (Ireland) Limited
320 Harolds Cross Road, Dublin 6
Telephone 961877
Telex 4596 Torn El
Italy
SIVI Illuminazione SpA
Casella Postale 604, 36100 Vicenza
Telephone (0444) 59 51 00
Telex 480049 Sivi-1
New Zealand
THORN EMI Lighting (NZ) Limited
PO Box 71134, 399 Rosebank Road,
Avondale, Auckland 7
Telephone 887 155
Telex NZ 2648
Norway
THORN EMI Belysning A/S
Brobekkveien 107
Oslo 5
Telephone (02) 642-800
Telex 76928 Atlas N
South Africa
THORN EMI Lighting (Pty) Limited
PO Box 43075
corner Watt and Edison Streets
Industria 2042, Transvaal
Telephone 839 2434
Telex J 0149
Sweden
THORN EMI Belysning AB
Anderstorpsvägen 4, Box 4203,
17104 Solna
Telephone 08-834 100
Telex 10106 Thornab S

Printed in England